CLAIMS

1. Apparatus for removing particles from the surface of a substrate, comprising:

a moving chuck, which is configured to receive the substrate and to move the substrate; and

an optical arm, which is adapted to direct a beam of electromagnetic energy onto the surface of the substrate, causing the particles to be dislodged from the surface, the arm being movable, in cooperation with the movement of the chuck, in order to scan the beam over the surface so as to impinge upon substantially any point on the surface from which the particles are to be removed.

2. Apparatus according to claim 1, wherein the apparatus is adapted to receive input position coordinates of the particles on the surface, and to direct the beam by movement of the chuck and the arm so that the beam is incident on the surface at the position coordinates of the particle.

3. Apparatus according to claim 2, wherein the optical arm is adapted to rotate about a base thereof so as to scan the beam according to the particle position coordinates.

4. Apparatus according to claim 2, and comprising a particle localization unit, which is adapted to determine the input position coordinates.

5. Apparatus according to claim 1, wherein the electromagnetic energy comprises laser energy.

6. Apparatus according to claim 5, and comprising a laser module adapted to generate the laser energy and a

radiation guide coupled from the laser module to the optical arm by so as to supply the beam of electromagnetic energy thereto.

7. Apparatus according to claim 6, wherein the laser module comprises a multi-wavelength laser module, which is adapted to supply the electromagnetic energy at a plurality of wavelengths.

8. Apparatus according to claim 6, wherein the laser energy comprises infrared radiation.

9. Apparatus according to claim 6, wherein the laser module comprises an Optical Parametric Oscillator (O.P.O.) which is tunable to match the energies required to remove a specific type of contaminant from the surface.

10. Apparatus according to claim 6, wherein the laser energy is Er:YAG laser energy.

11. Apparatus according to claim 6, wherein the laser energy is CO_2 laser energy.

12. Apparatus according to claim 1, wherein the optical arm comprises a channel for conveying a vapor to the surface of the substrate.

13. Apparatus according to claim 12, wherein and the channel terminates in a nozzle adjacent to the substrate surface.

14. Apparatus according to claim 1, wherein the optical arm comprises an outlet channel, which is adapted to be coupled to a suction system.

15. Apparatus according to claim 14, wherein the outlet channel comprises a suction nozzle adjacent to the substrate surface.

16. Apparatus according to claim 15, wherein the suction nozzle has an aperture of approximately 0.5 to 3 cm.

17. Apparatus according to claim 15, wherein suction nozzle is held no more than 4 cm above the substrate surface.

18. Apparatus according to claim 17, wherein the suction nozzle is placed approximately 2 cm above the substrate surface.

19. Apparatus according to claim 1, wherein the chuck is adapted to rotate in a plane of the substrate about a central axis thereof and to move along a radius thereof.

20. Apparatus according to claim 1, wherein the chuck is adapted to move linearly in a plane of the substrate along x and y axes.

21. Apparatus according to claim 1, wherein the arm is adapted to rotate about a base thereof in a plane parallel to the substrate.

22. Apparatus, according to claim 1, wherein the substrate comprises a semiconductor wafer.

23. A cluster tool for processing a semiconductor wafer, comprising:

a processing chamber, adapted to receive the wafer and comprising apparatus for forming features on the wafer;

a particle removal unit, adapted to receive the wafer and comprising an optical assembly for directing a beam of electromagnetic energy onto a surface of the wafer so as to dislodge contaminants from the surface; and

a wafer transfer mechanism, coupled to transfer the wafer between the processing chamber and the particle removal station substantially without exposing the wafer to ambient air.

24. Apparatus according to claim 23, wherein the electromagnetic energy comprises laser energy.

25. Apparatus according to claim 23, wherein the optical assembly comprises an optical arm, which is coupled to receive the beam of electromagnetic energy and is movable so as to scan the beam over the surface.

26. Apparatus according to claim 25, wherein the particle removal unit comprises a substrate-holding chuck, adapted to move the wafer in cooperation with movement of the arm so that the beam can impinge at substantially any point on the surface of the wafer.

27. Apparatus according to claim 23, wherein the particle removal unit is adapted to receive input position coordinates of the particles on the surface, and to direct the beam responsive to the coordinates of the particles.

28. Apparatus according to claim 27, and comprising a particle localization unit, which is adapted to determine the input position coordinates.

29. Apparatus according to claim 28, wherein the wafer transfer mechanism is adapted to transfer the wafer to and from the particle localization unit substantially without exposing the wafer to ambient air.

30. Apparatus according to claim 23, wherein the particle removal unit comprises a cleaning module, which is adapted to receive the wafer, and a laser module and radiation guide, wherein the laser module is situated

remotely from the cleaning module and is coupled to the optical arm by a radiation guide so as to supply the beam of electromagnetic energy thereto.

31. Apparatus according to claim 23, wherein the optical arm comprises one or more channels adapted to convey materials to or from the surface of the wafer.

32. Apparatus according to claim 31, wherein the one or more channels comprises a vapor channel, for conveying a vapor to the surface of the wafer.

33. Apparatus according to claim 31, wherein the one or more channels comprise a suction channel, for removal of contaminants from a vicinity of the wafer.

34. A method for removing particles from the surface of a substrate, comprising:

positioning the substrate under an optical arm;

directing a beam of electromagnetic energy through the optical arm onto an area of the surface of the substrate, so as to dislodge particles in the area from the surface; and

moving the optical arm and the substrate in cooperation so as to cause the beam to impinge upon substantially any point on the surface from which the particles are to be dislodged.

35. A method according to claim 34, and wherein moving the arm and substrate in cooperation comprises:

receiving input position coordinates of the particles on the surface; and

positioning the arm and substrate in response to the input position coordinates.

36. A method according to claim 34, wherein the electromagnetic energy comprises laser energy.

37. A method according to claim 36, wherein directing the beam of electromagnetic energy comprises coupling the optical arm by a radiation guide to a remote laser module.

38. A method according to claim 36, wherein directing the beam of electromagnetic energy comprises supplying the laser energy at a plurality of wavelengths.

39. A method according to claim 38, wherein supplying the laser energy at the plurality of wavelengths comprises tuning the energy to a wavelength optimized for a particle removal process by which the particles are to be dislodged.

40. A method according to claim 39, and comprising wetting the surface with a fluid before directing the beam of electromagnetic energy, and wherein tuning the energy comprises tuning the wavelength to facilitate absorption of the energy by the fluid.

41. A method according to claim 40, wherein directing the beam of electromagnetic energy comprises directing the beam at the tuned wavelength with an energy sufficient to cause explosive evaporation of the fluid substantially without damage to the substrate.

42. A method according to claim 34, and comprising conveying a vapor to the surface of the substrate via the arm, wherein directing the beam of electromagnetic energy comprises directing the beam onto the surface with an energy sufficient to cause explosive evaporation of the fluid substantially without damage to the substrate.

43. A method according to claim 34, and comprising applying suction via the arm so as to remove matter from a vicinity of the substrate surface.

44. A method according to claim 34, wherein moving the arm and the substrate comprises rotating the substrate about a central axis thereof.

45. A method according to claim 34, wherein moving the arm and the substrate comprises moving the substrate linearly in a plane of the substrate.

46. A method according to claim 32, wherein moving the arm and the substrate comprises rotating the arm about an axis passing through a base thereof.

47. A method for processing a semiconductor wafer, in a cluster tool comprising:

forming features on a surface of the wafer in a processing chamber;

transferring the wafer between the processing chamber and a particle removal unit substantially without exposing the wafer to ambient air; and

directing a beam of electromagnetic energy onto the surface of the wafer so as to dislodge contaminants from the surface.

48. A method according to claim 47, wherein the electromagnetic energy comprises laser energy.

49. A method according to claim 47, and comprising receiving input position coordinates of the contaminants on the substrate surface, wherein directing the beam comprises aiming the beam responsive to the input position coordinates.

50. A method according to claim 49, wherein receiving the input position coordinates comprises

transferring the wafer to a particle localization unit for determination of the coordinates, substantially without exposing the wafer to ambient air.

51. A method according to claim 47, wherein directing the beam comprises conveying the beam via a radiation guide from a remote laser module to a cleaning module, which receives the wafer without exposing the wafer to the ambient air.